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# MULTIMEDIA UNIVERSITY

## FINAL EXAMINATION

TRIMESTER 1 , 2018/2019

**ERT3026 – AUTOMATION**  
(RE)

26 OCTOBER 2018  
3.00 p.m. – 5.00 p.m.  
(2 Hours)

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### INSTRUCTIONS TO STUDENT

1. This Question paper consists of 7 pages including cover page and Appendix with 4 Questions only.
2. Attempt **ALL** questions. The distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

### Question 1

- (a) Design a programmable logic controller (PLC) ladder diagram to control forward and reverse running of the motor as shown in the **Figure Q1(a)** by using the Input/Output assignment as shown in **Table Q1(a)**.

This is possible by using two switches forward switch (X0) and reverse switch (X1) and the operation condition as follows:

- The forward switch is pressed and then after 1 second, contactor Y0 will be enable and the motor run forward.
- The reverse switch is pressed and then after 2 second, contactor Y1 will be enable and the motor run reverse.
- Y0 and Y1 will be disabling and the motor will stop running.

[17 marks]

**Table Q1-(a) The Input/Output Assignment for Question 1(a)**

| Input Address  | Input Devices           |
|----------------|-------------------------|
| 0.00           | Push Button Switch (X0) |
| 0.01           | Push Button Switch (X1) |
| 0.02           | Push Button Switch (X2) |
| T0000          | Timer for 1 sec         |
| T0001          | Timer for 2 sec         |
|                |                         |
| Output Address | Output Devices          |
| 2.00           | Forward Running (Y0)    |
| 2.01           | Reverse Running (Y1)    |

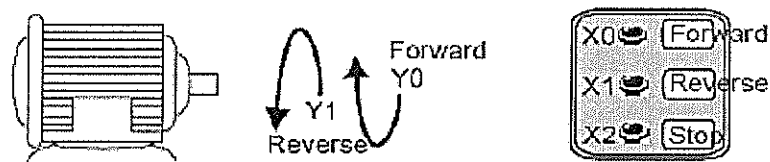


**Figure Q1.(a): Motor for Question 1(a)**

Continued...

- (b) Design a programmable logic controller (PLC) ladder diagram to satisfy the following condition.
- The input switch is labelled as 0.00 and the output as 2.00.
  - When the input switch is turn on, the timer will start counting 5 seconds.
  - Then, the light will ON.

[7 marks]

- (c) Design the ladder logic diagrams for the following Boolean logic equations:

(i)  $Y = (X1 + X2) \cdot X3$  [3 marks]

(ii)  $Y = (X1 + X2) \cdot (X3 + X4)$  [3 marks]

Where X1, X2 , X3 and X4 are inputs and Y is the output.

## Question 2

A plastic injection molding plant will be built to produce 5,000,000 molded parts/yr. The plant will run 2 shifts per day, 8-hr per shit, five days/wk, and 52 wk/yr.

For planning purposes, the average batch size is 10000 moldings, average changeover time between batches is 3hr, and average molding cycle time per part is 18 sec.

Assume scrap rate is 3%, and availability for each molding machine is 100%, which applies to both run time and changeover time.

- (a) How many molding machines are required in the new plant? [15 marks]
- (b) Determine the time required to produce each batch. [5 marks]

Continued ...

**Question 3**

An eight-station rotary indexing machine performs the machining operations as shown in the **Table Q3**. The transfer time for the machine is 0.15 min per cycle.

A study of the system was undertaken, during which time 3000 parts were completed. It was determined in this study that when breakdown occur, it takes an average of 8.0 min to make repairs and get the system operating again.

For the study period, determine the following.

- (a) Average actual production rate, [12 marks]
- (b) Line uptime efficiency, and [4 marks]
- (c) Required operation hours to produce the 3000 parts. [4 marks]

**Table Q3**

| Station | Process         | Process time | Breakdowns |
|---------|-----------------|--------------|------------|
| 1       | Load part       | 0.50 min     | 2          |
| 2       | Mill top        | 0.85 min     | 46         |
| 3       | Mill sides      | 1.10 min     | 80         |
| 4       | Drill two holes | 0.60 min     | 10         |
| 5       | Ream two holes  | 0.43 min     | 30         |
| 6       | Drill six holes | 0.92 min     | 59         |
| 7       | Tap six holes   | 0.75 min     | 21         |
| 8       | Unload part     | 0.40 min     | 2          |

**Continued ...**

### Question 4

A semi-automated flexible manufacturing cell (FMC) is used to produce three products. The products are made by two automated processing stations followed by an assembly station. There is also a load/unload station. Material handling between stations in the FMC is accomplished by mechanized carts that move tote bins containing the particular components to be processed and then assembled into a given product. The carts transfer tote bins between stations. In this way the carts are kept busy while the tote bins are queued in front of the workstations. Each tote bin remains with the product throughout processing and assembly. The details of the FMC can be summarized as shown in **Table Q4.1**:

**Table Q4.1**

| Station | Description     | Number of servers                    |
|---------|-----------------|--------------------------------------|
| 1       | Load and unload | 2 human workers                      |
| 2       | Process X       | 1 automated server                   |
| 3       | Process Y       | 1 automated server                   |
| 4       | Assembly        | 2 human workers                      |
| 5       | Transport       | Number of carriers to be determined. |

The product mix fractions and station processing times for the parts are presented in the **Table Q4.2**. The same station sequence is followed by all products: 1→2→3→4→1.

**Table Q4.2**

| Product | Product mix | Station 1 | Station 2 | Station 3 | Station 4 | Station 1 |
|---------|-------------|-----------|-----------|-----------|-----------|-----------|
| A       | 0.35        | 3 min     | 9 min     | 7 min     | 5 min     | 2 min     |
| B       | 0.25        | 3 min     | 5 min     | 8 min     | 5 min     | 2 min     |
| C       | 0.40        | 3 min     | 4 min     | 6 min     | 8 min     | 2 min     |

The average cart transfer time between stations is 4 minutes.

- What is the bottleneck station in the FMC, assuming that the material handling system is not the bottleneck? [15 marks]
- At full capacity, what are the overall production rate of the system and the rate for each product? [6 marks]
- Determine the minimum number of carts in the material handling system required to keep up with the production workstations. [3 marks]
- Compute the utilization for each station. [6 marks]

**End of Page**

## APPENDIX

TABLE 1: Some Useful Formulas

|                                                           |                              |                                                             |                                                                 |
|-----------------------------------------------------------|------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------|
| $R_p = \frac{1}{T_p}$                                     | $T_c = T_m + T_s$            | $T_c = \frac{S_p}{v_c}$                                     | $T_t = \frac{L_s}{v_c}$                                         |
| $WL = \frac{Q T_c}{1 - q}$                                | $n = \frac{WL}{AT}$          | $n = \frac{W}{M}$                                           | $AT = S_w H_{sh} AU$                                            |
| $T_c \leq \frac{E}{R_p}$                                  | $E_b = \frac{T_{wc}}{n T_s}$ | $T_c = \text{Max}\{T_m, T_s\} + T_r$                        |                                                                 |
| $D = \frac{FT_d}{T_p}$                                    | $E = \frac{T_c}{T_p}$        | $T_s = \text{Max} T_{si} \leq T_{mc} - T_r$                 |                                                                 |
| $T_c = T_L + \frac{L_d}{v_c} + T_U + \frac{L_e}{v_e}$     |                              | $T_p = T_c + FT_d$                                          |                                                                 |
| $F = \sum_i^n p_i$                                        |                              | $F = 1 - \left[ \prod_{i=1}^n (1 - p_i) \right]$            |                                                                 |
| $T_{wc} = \sum_{j=1}^{n_e} T_{ej} = \sum_i^n T_{si}$      |                              | $d = \frac{nT_s - T_{wc}}{nT_s}$                            |                                                                 |
| $WL_i = \sum_j \sum_k t_{ijk} f_{ijk} p_j$                |                              | $n_t = \left( \sum_i \sum_j \sum_k f_{ijk} p_j \right) - 1$ |                                                                 |
| $WL_{n+1} = n_t t_{n+1}$                                  |                              | $BS_i = WL_i(R_p^*)$                                        |                                                                 |
| $R_p^* = \frac{s^*}{WL^*}$                                |                              | $R_{pj}^* = p_j(R_p^*)$                                     |                                                                 |
| $U_i = \frac{WL_i}{s_i}(R_p^*)$                           |                              | $\bar{U} = \frac{\sum_{i=1}^{n+1} U_i}{n+1}$                | $\bar{U}_s = \frac{\sum_{i=1}^{n+1} s_i U_i}{\sum_{i=1}^n s_i}$ |
| $N^* = R_p^* \left( \sum_{i=1}^n WL_i + WL_{n+1} \right)$ |                              |                                                             |                                                                 |

TABLE 2: Extended Bottleneck Model

| Case 1: $N < N^*$                      | Case 2: $N \geq N^*$                         |
|----------------------------------------|----------------------------------------------|
| $MLT_1 = \sum_{i=1}^n WL_i + WL_{n+1}$ | $R_p^* = \frac{s^*}{WL^*}$                   |
| $R_p = \frac{N}{MLT_1}$                | $R_{pj}^* = p_j(R_p^*)$                      |
| $R_{pj} = p_j R_p$                     | $MLT_2 = \frac{N}{R_p^*}$                    |
| $T_w = 0$                              | $T_w = MLT_2 - \sum_{i=1}^n WL_i + WL_{n+1}$ |